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VOL. I --SUMMARY

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OCD Subtask 2311
Contract No. OCD-OS-63-109

Prepared for

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Washington, D. C. 20310

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VULNERABILITY REDUCTION USING MOVEMENT AND SHELTER

SUMMARY

This report describes an effort to find preferred mixtures of movement and shelter as Civil Defense responses to the threat of nuclear war. The study may be placed in perspective with the aid of Fig. 1 and some intuitive arguments.

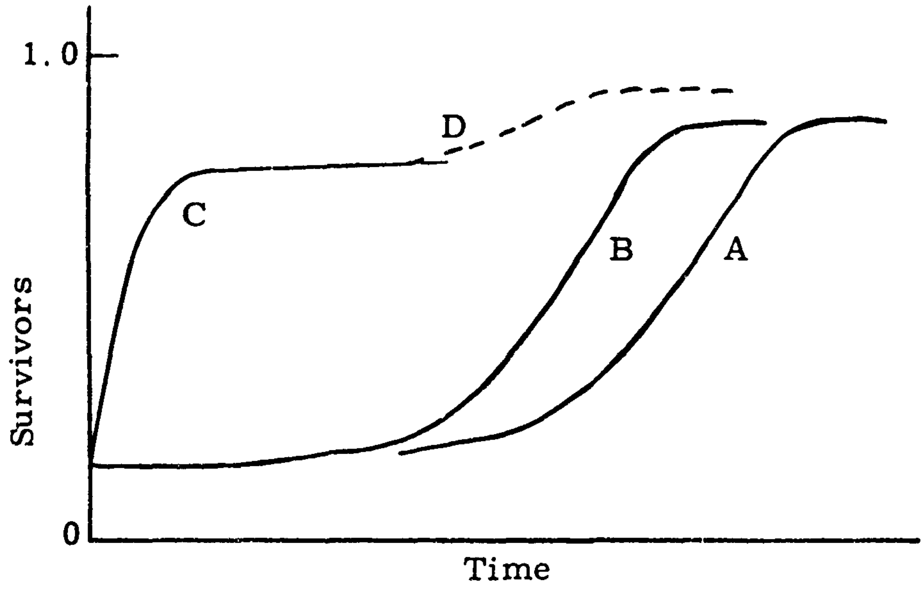

Fig. 1

Survivors Versus Time for
Various Movement and Shelter Policies

With very long action times (time between decision to act and arrival of lethal effects) complete evacuation of a city could be carried out. The immediate survival rate would be essentially 100% if the evacuated city were bombed. This survival rate must be reduced by fallout casualties in the reception area, but given sufficient time, improvised fallout protection

can be provided, and a very high attack survivor rate can be achieved (Curve A in Fig. 1). If fallout protection were already available in the reception area, the action time required to achieve this survival rate would be reduced (Curve B). If shelters (from initial effects as well as fallout) were provided in the target area and the population vulnerability decreased for short action times, there would still be enough people killed either directly or indirectly that the total survival rate would probably be smaller than that possible with evacuation and a long action time (Curve C). Combinations that evacuate those in the most vulnerable locations and provide shelter for those in somewhat safer positions might lead to survival curves like the dashed curve (Curve D).

The development of realistic curves of the types shown in Fig. 1 may be done in three major steps:

1. Postulation of alternative movement and shelter policies,
2. Development of movement and shelter plans based on the policies in (1), and
3. Evaluation of plans developed in (2) against the range of attack conditions considered reasonable. Completion of this step permits the preparation of curves of the types shown in Fig. 1.

In carrying out the first step one would hope to postulate as many reasonable policies as imagination allows; this is largely an intuitive step. Once a policy is postulated, techniques for preparation of plans to carry it

out can be constructed. Then, it is appropriate to evaluate the plans in the range of environments that can be expected. This last step requires application or development of the analysis tools needed to draw curves of the type represented in Fig. 1.

Technical Publications

The following technical notes were published under this contract:

1. DC-TN-1039-1, Large-Scale Strategic Movement Planning.
2. DC-TN-1039-2, A Model for Development of Preferred Mixtures of Evacuation and Shelter.
3. DC-TN-1039-3, A Computer Program for Calculating Shelter Hardness and Cost for Uniform Survival Probability.
4. DC-TN-1039-4, Time-Geographic Population Distributions.
5. DC-TN-1039-5, A Computer Program for Calculating Fatalities Among Evacuees Enroute When an Attack Begins.
6. DC-TN-1039-6, A Computer Program for Calculating Minimum Cost Movements.
7. DC-TN-1039-7, A Computer Program for Calculating the Expected Cost per Survivor for a Uniform Shelter Design Overpressure Policy.
8. DC-TN-1039-8, A Computer Program for Calculating Casualties From the Initial Effects of Nuclear Weapons.
9. DC-TN-1039-9, A Computer Program for Planning a Strategic Movement.
10. DC-TN-1039-10, A Computer Program for Finding the Order of Expenditure on Blast Shelters that Maximizes Additional Survivors per Dollar.

More complete references to these notes may be found at the end of Vol. II of this report.

Technical Notes 1, 6, and 9 were prepared to form a basis for planning strategic movements; as such, they permit completion of Step 2 in the development of curves of types A and B in Fig. 1. Step 3, the evaluation step, may be performed with the aid of computer programs described in Technical Notes 5 and 8. Technical Note 4 discusses some ways in which time-geographic population distributions could be obtained as input data for the casualty-calculation program described in Technical Note 8.

Technical Notes 3, 7, and 10 discuss some computer programs that can be used to plan blast shelter systems (Step 2 for shelter systems). The evaluation (Step 3) of such shelter plans to calculate curves of type C in Fig. 1 can be carried out using standard target analysis techniques.

Technical Note 2 reports the development of a mathematical model for finding preferred mixtures of shelter and movement. This approach is completely independent of the one represented by development of the curves in Fig. 1.

All of the computer programs prepared under this contract were written in FORTRAN and may be obtained by writing to Dikewood through the following office:

Department of the Army
Office of the Secretary of the Army
Office of Civil Defense
Attn: Support Systems Research
Washington, D. C. 20310

Strategic Movement

Strategic movement has long been understood to be a movement policy worthy of study. A number of OCD contractors have considered the problem, and Dikewood's efforts conducted under past and present contracts are discussed in this report. The most significant finding is that fatalities can be reduced to 0-20% of those associated with no response to warning of a heavy attack (NAHICUS '63). This assumes sufficient time to move from potential target cities to existing housing in non-target areas and, in the event an attack occurs, to fallout shelter existing today in non-target areas. In most areas this implies only the fallout shelter provided by a house (PF=2) or basement (PF=20). A number of questions concerning housing, transportation, and fallout shelter were examined and none of the results obtained indicate strategic movement to be infeasible. In view of these findings, Step 2 in the above sequence was undertaken. This led to development of a technique for planning strategic movements and to checking the technique by preparing a movement plan using Albuquerque as an example.

Techniques for evaluating strategic movement plans in the face of particular attacks were also developed (Step 3). These techniques can be applied to obtain curves of types A and B in Fig. 1, and a limited number of such applications were made to find survivor-versus-time curves for an attack on Albuquerque that takes place at various times after the above-mentioned strategic movement plan is started.

Other Movement Strategies

Movement planning techniques developed under this contract for planning strategic movements may be found useful for planning a number of other CD threat responses. Movement to shelter, remedial movement, rescue, and movement as an interim solution to the shelter deficit are examples.

It should be pointed out that a complete theoretical basis for planning movements is not yet available. No solution has been found that minimizes target city empty time or that minimizes reception area fill time. Two movement planning programs were developed in the present effort; one of these minimizes man-miles traveled and the other appears to minimize reception area fill time. The logic in the latter program is essentially heuristic. Although it provides solutions that seem reasonable and practical, further work on a more rigorous technique seems appropriate. D. R. Fulkerson of RAND Corporation has indicated that he can describe a project that may lead to solutions for these two problems.

Some Shelter Design Policies

Five shelter system design policies are considered in varying degrees of detail; they are:

1. Uniform maximum fatalities per incoming weapon.
2. Uniform probability of survival.
3. Uniform shelter design overpressure.

4. Maximum added survivors per dollar expended.

5. Maximum enemy cost per kill.

As the above short title implies, Policy 1 leads to a choice of shelter hardness that depends on population density, i.e., the higher the density, the harder the shelter. This choice therefore limits the maximum number of fatalities given up per incoming weapon to some preselected number.

Computer programs for designing systems based on Policies 2, 3, and 4 were developed under this contract. The program for Policy 4 can also be used to find a preferred order of expenditure for other CD programs, e.g., thermal hardening.

A program for designing a system based on Policy 5 can be extracted quite easily from those developed for Policies 2, 3, and 4, but this has not been done.

These five policies represent an attempt to satisfy Step 1 in the sequence outlined above to develop curves of type C in Fig. 1. The computer programs mentioned present a means for carrying out the design of plans (Step 2). This step has been done in only a very limited way for Albuquerque using the programs for Policies 2, 3, and 4. Step 3 has not been started, but it is a simple one to carry out.

A Mathematical Model for Finding Preferred Movement-Shelter Mixtures

In addition to following the rather detailed approach outlined above for the development of preferred mixtures of movement and shelter, another

more general approach was taken. In this approach, the overall probability of survival of a group is related to initial position relative to a single aiming point, speed and direction of movement, a choice of warning time probability density functions, shelter location and hardness, weapon yield, and delivery error (CEP). An expression is developed that allows one to find mixtures of shelter and movement that maximize over-all survival probability, given assumptions about the other variables. The expression may be used to determine, as a function of movement distance, the shelter hardness required to keep overall survival probability at a constant maximum value. The expression may also be used to find the "optimum" take-shelter location for a shelter system designed on another basis. Finally, it may be applied to decide where to build shelters of a given cost (hardness) in order to maximize overall survival probability. A computer program was developed to permit rapid application of the technique.

Conclusions and Recommendations

1. Strategic movement from potential target cities to fallout shelter available today in non-target areas can reduce fatalities to 0-20% of those associated with no response to warning of a heavy attack.

2. A technique has been developed that can be used to prepare a basis for a national strategic movement capability. It is recommended that the technique be applied nationally and that the resultant plans be made available for preparation of more detailed local plans for strategic movement.

3. Two generalized movement planning techniques have been developed. However, theoretical understanding of the problem is still incomplete. It is recommended that additional study be performed to develop a movement planning technique that can be shown to lead to a minimum empty time for population sources (areas with population that needs to be moved) and, possibly, for a second technique that leads to a minimum fill time for population sinks (reception cities, shelters, etc.). This study, if successful, might be applied to the first revision of a strategic movement plan, to movement-to-shelter planning, and to remedial movement and rescue planning.

4. Techniques have been developed that permit planning and evaluation of various movement-shelter alternatives for particular places. It is recommended that these techniques be applied in detail to one or more of the Five Cities. Fire effects should be incorporated into the analysis technique as soon as they are understood well enough to produce meaningful results.

5 A mathematical model has been developed for finding preferred mixtures of shelter and movement. It is recommended that this model be used to perform a sensitivity analysis of the problem.